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IRRIGATE
User guide for irrigation management by computer

Canada

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IRRIGUE Manuel de l'utilisateur pour la gestion informatisée de l'irrigation

Cover illustration
The dots on the map represent Agriculture Canada research establishments.

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PREFACE

The software described here is the BASIC microcomputer version of a soil moisture model (VB4) developed initially by W. Baier and G.W. Robertson from the agrometeorology section, Agriculture Canada. There is also a Fortran version for IBM-PC, VAX and IBM-370. For more information on the theoretical aspects of irrigation scheduling or the model one can refer to Dyer and Mack (1984) or Hobbs and Krogman (1983).

This version has been primarily written for the daily management of water in irrigation. It is considered a complementary tool to assist in judging the severity and the frequency of stress during the growing season. Its most interesting output is an estimation of the number of days before an irrigation is required. It can also provide estimates of the soil water status within the whole profile and the water deficit in the root zone. It can take into account many fields each having a specific crop and soil, irrigated or not.

This software was first tested by potato growers in various rural areas in Quebec. Its use was extended to other crops and provinces after receiving specific requests.

It appears that the initialization phase of the software is critical for acceptance of this technique. Some concepts such as available water, field capacity, permanent wilting point, crop coefficients may remain vague for some, even after a close reading of this guide. In this case, we suggest that the readers contact their local agronomist. This specialist will be able to answer their questions and to advise them on the step to follow to get the right soil analysis.

The authors want to thank the farmers and the agronomists who have participated in the evaluation of IRRIGATE. In alphabetical order: Mario Arcand, Bruno Belanger, Helene Boisvert, Fernando and Gaston Bouchard, Lucie and Rene Deschambault, Vital Dolbec, Les Entreprises Salomon, Remi Fortin, Sylvain Laurin, Madeleine Lemay, J.-G. Richard and Jacques Rioux. We wish to thank Dr. R. de Jong, Dr. P. Rochette and K. Samuel for reviewing the guide.

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HOW TO USE THIS GUIDE

It is not necessary to read all this user guide to use the software. First, make sure you have the appropriate equipment (section 2.1) then go to the second part and follow the instructions stepwise. Annex A provides the definitions of the technical terms.

Before using IRRIGATE in real time, read carefully section 2.2 (first part) to be sure you have the required data.

During the growing season, read section 2.3 (first part) to know how to verify that the software is giving reliable information.

When the software and the principles are well understood, section 3.0 will explain various applications of IRRIGATE.

Models are never perfect, and this one is no exception. Limitations of the software are explained in section 4.0. Annex D details the structure of the files created by IRRIGATE.

FIRST PART: GENERAL INFORMATION

1. INTRODUCTION

Irrigation is a reliable technique to prevent negative effects of water stress on yields for many crops. Good management of the irrigation system will help to reduce costs and increase yields.

There are three methods to determine if there is enough available water in the soil for the crop: visual, measurements and budgeting. Visual assessment is done by observing the crop; it gives qualitative information. Use of techniques like gravimetric determination or instruments like tensiometers, neutron probe, TDR, etc., will give reliable specific point information on the status of water in the soil. Taken alone, neither method allows evaluation of the future needs of the crop, nor scheduling of the next irrigation nor evaluation of long-term needs in terms of the irrigation system.

The third method is to use a soil moisture budget. Rainfall is measured and evaporation is calculated from climatic observations (e.g. temperature, solar radiation). When rainfall is less than evaporation, the difference is the amount to irrigate. By taking into account the effects of plant stage, rooting depth, soil, variety, etc. on soil water used by the plants, the calculations become very complex. At this point, computer software becomes very useful. The software can be combined with an automatic weather station.

Irrigation software used with soil moisture measurements will provide a versatile tool well adapted to a specific soil and crop.

2. BASIC REQUIREMENTS

2.1 Computer and hardware

This software works on IBM-PC and on IBM-PC compatible computers. At least one disk drive is required. Some files are direct access. The executable basic version requires about 65K of internal memory.

2.2 Data to be provided

Precision and reliability depend on the right choice of the parameters describing soil and plant characteristics. The software cannot be better then the basic information provided.

There is a minimum amount of information that must be provided to the software. These data are summarized in table 1. There are four groups of information: soil, crop, weather and irrigation.

TABLE 1: List of the basic data to be provided to the program

SOILS DATA
Field Capacity (%)
Permanent wilting point (%)
Saturation value (%)
Soil moisture at a starting date (%)
METEOROLOGICAL DATA
Maximum daily temperature (^{o}C)
Minimum daily temperature (^{o}C)
Daily precipitation in mm
PHENOLOGICAL DATA
Seeding, planting or growing season starting date
Main phenological stage dates
Harvest or end of growing season date
IRRIGATION
Date of irrigation
Amount of water added (mm)

SOIL DATA:

These data are input once at the beginning of the season. They describe the type of soil in the root zone. If there is more than one type of soil, the characteristics of each type should be defined for specified zones.

Required soil characteristics are:

- field capacity (%): water content of the soil 1 or 2 days after the soil has been saturated by rain or irrigation and free drainage has practically ceased. It is also the water contained in a soil after applying a pressure of 1/3 bar.

- permanent wilting point (%): water content of the soil where plants wilt and fail to recover their turgidity when placed in a dark, humid atmosphere. It is commonly estimated in laboratory by applying a pressure of 15 bars.

- soil moisture at saturation (%): water content of the soil when all the voids between soil particles are filled with water.

- depth of zone (cm): the distance from the surface to the bottom of each specified zone.

Figure 1 suggests values according to the soil type if an analysis is not available.

The budget must be initialized by providing the soil moisture at a certain starting date. If an observed soil moisture is not available, that date can be fixed on the day following a good rain when the soil is expected to be at field capacity.

Soil moisture, field capacity and permanent wilting point may be expressed in terms of percentage by weight or volume. However, the same units should be used consistently throughout.

CROP DATA:

Required crop data include the seeding, planting or growing season starting date and the main phenological stage dates. These dates are related to rooting depth, ground cover and the various needs of the plant for water. A crop coefficient (fig. 2) must be provided for each date. The software will do an interpolation of the crop coefficient between two dates. The fluctuations of the coefficients are usually similar to the standard curve in figure 2. On this figure, five stages were used to describe the curve shape; at least one stage must be provided. More than one harvest date can be defined.

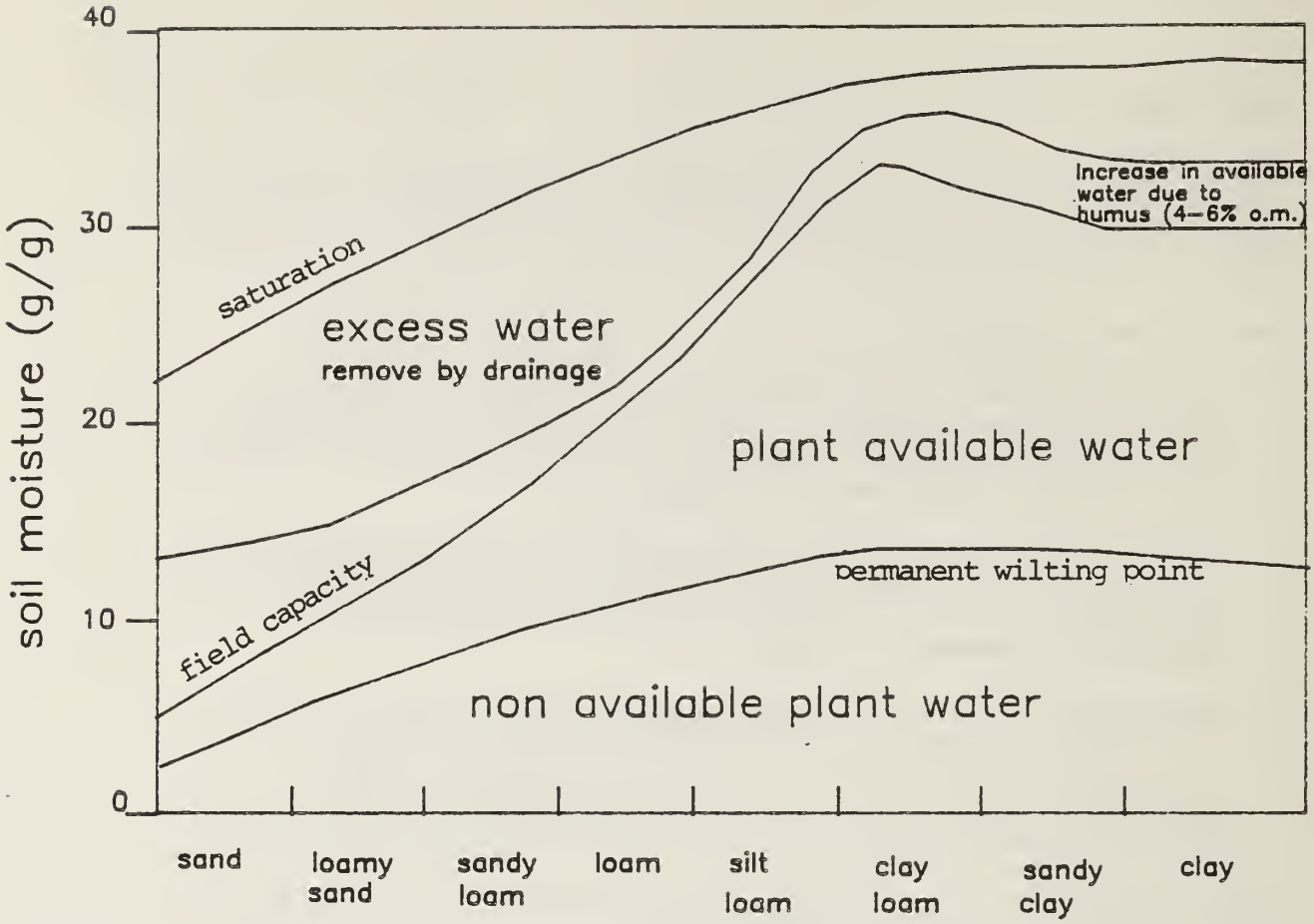

Figure 1. Soil moisture characterisitcs for various textures.
Source: Côté, D. 1986.

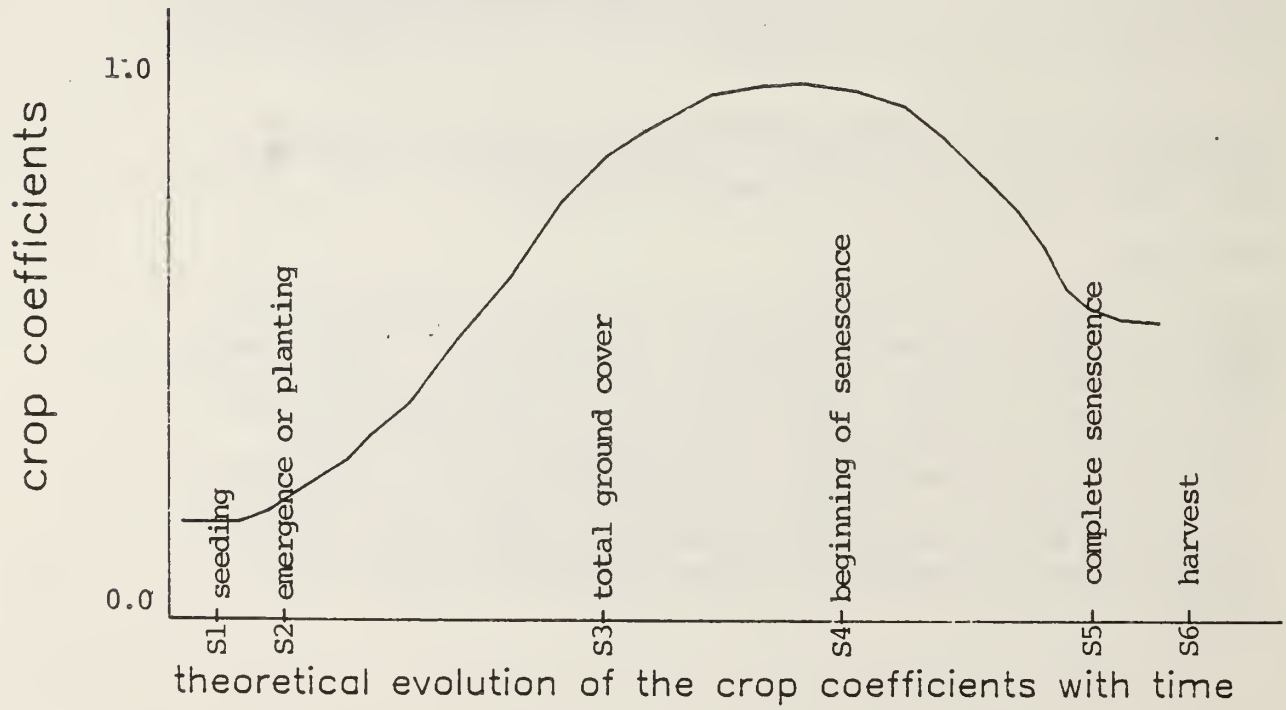

Figure 2. Variation of the crop coefficients with stages. Maximum is usually around 1.0 but varies with plants and authors. S1 .. S6: stages to define in the software.

METEOROLOGICAL DATA AND IRRIGATION:

The required meteorological data are daily maximum temperature (Celsius), daily minimum temperature (Celsius) and daily precipitation (mm). These data can be measured directly on the farm or taken from the closest climatological station.

On-farm measurements of temperature and rainfall should be made using standards and equipment approved by the Atmospheric Environment Service (A.E.S.). Temperature are normally recorded in a standard weather shelter mounted 1.3 m above ground. Rain gauges need to be located sufficient distances from tall obstacles but should also reflect water received by the irrigated field.

The amount of water supplied to the soil by irrigation must be measured and entered in mm. The software does not take into account the type of irrigation system. The measurement is made by using a rain gauge.

2.3 How to use irrigation software

Once basic data are obtained, the software can be run. Initialisation must be done first with soils and crops data. Then daily meteorological data can be introduced. Available water will be calculated for each day and a forecast for the next required irrigation will be given.

To get reliable results, software must be validated and adjusted at the farm. Validation ensures that estimates from the software correspond to the real field situation. It is strongly recommended to calibrate the program by taking field soil moisture measurements. The most common technique is gravimetric. Measurements should be compared with values estimated by the software. Large variations indicate a need to look for faulty parameters.

The software is calibrated by using a trial and error method. To adjust a parameter, a range of values of the parameter from extreme minimum to maximum are tried. The differences between observed and estimated soil moisture are compared and the best value is the one giving the smallest difference.

Differences of 2% or more in soil moisture are common within a field. It is not necessary to get a precise adjustment between the results of the models and the values observed. The software must provide a mean value of the conditions prevailing in the field.

Even if laboratory analyses are available, the following parameters may require an adjustment: saturation, field capacity, permanent wilting point, drainage/runoff coefficient, crop coefficients.

These parameters often interact with each other; changing one can therefore affect the others. Also, sufficient observations are required to accurately judge the effects of a parameter. Following are some useful tips on parameter adjustment:

1) Do some checks on the validity of the observations. If there was no rain since the last sampling, the soil will be drier and the observations should be lower. At the other end, if there was excessive rain, measurements should reflect field capacity or saturation;

2) Permanent wilting point is the lowest soil moisture value that the software can estimate. If observations are lower, they may be wrong or the permanent wilting point should be decreased, particularly if the plants do not look wilted;

3) If the theoretical field capacity is too low, the software will under-estimate soil moisture systematically. If it is too high, estimated soil moisture will almost always be greater than the observed values. Field observation is often the best indicator to set that value;

4) A saturation level set too low will under-estimate soil moisture after a replenishing rain. If too high, it will over-estimate soil moisture. The effects of this parameter are noticeable only after a lot of rain;

5) If the drainage/runoff coefficient is too low, soil moisture estimated by the model will remain above field capacity for a longer period of time than really observed in the field. It is the contrary if it is too high. This coefficient will not have any effect if the soil is at or below field capacity;

6) Adjustment of crop coefficients is more touchy; it should come last and requires a large number of observations. The coefficient is fixed for each stage; in between two stages, the program will do a linear interpolation. If the difference between observed and estimated soil moisture increases more at the end of a stage and at the beginning of the next stage, change the coefficient of the next stage. A coefficient too high will dry the soil more rapidly than the real conditions. If the differences are negative, the coefficient is too low; otherwise, it is too high. The effects of crop coefficients are noticeable mainly when the soil is moist; dry soil restricts the amount of water that can be extracted by the plant;

7) If the plants seem to need water and the estimated values correspond to the observed but the software does not indicate that irrigation is needed, then this means the value of the critical deficit defined with option 4 is too large. In that case, the value of the critical deficit should be decreased (option 4).

3. TIPS ON THE USE OF "IRRIGATE" IN MANAGEMENT

Irrigation software should be considered like a strategy game. Situations are simulated to make a decision or to analyze the consequences of a decision. With software well adapted to the soils and crops on the farm, the user will have a tool to judge the

severity and frequency of water stress during the growing season. The user will also be able to simulate what the results would have been with a different crop.

We will present some of the problems that could be solved with this software. They will be presented as questions and answers.

SITUATION 1: SOIL MOISTURE STATUS

Question: What is the soil moisture on a specific date?

Answer: Run the software (option 7). The values displayed are explained in section 2.0 of the second part. The column "soil water" gives the soil moisture in % for the whole profile at the end of the day after rain or irrigation if there was any during that day. The column "deficit" gives the amount of water in mm that should be added to the root zone to bring the soil to field capacity.

SITUATION 2: DAILY PLANNING OF IRRIGATION

Question: In how many days should we irrigate?

Answer: There are three possible methods on which a decision can be based.

Method 1: use column "Irrigation needed in" displayed with option 7 and interpret, talking the column "Demand for water" into consideration.

Method 2: use last year's weather data to look ahead. There are two ways to use last year's weather data file: 1) enter last year's data with option 2 and update the file with this year's data; or 2) use last year's weather data file by proceeding like this:
COPY Site.MET Site87.MET (stores last year's data on file Site87.MET)
then update the weather data file daily using option 2.

Method 3: use forecast weather data and insert these into the weather data file with option 2. Update the file with new forecast and observed daily data.

SITUATION 3: TO EVALUATE THE EFFECT OF AN IRRIGATION

Question: Precipitation was recorded after irrigation was done. Was it useful to irrigate?

Answer: Run the program twice or create 2 fields: one with irrigation and the other without irrigation. Compare the results in terms of the deficit. It happens often that the rain is not enough to replenish soil to its field capacity.

SITUATION 4: TO EVALUATE THE AMOUNT OF WATER ADDED OR THE FREQUENCY

Question: An irrigation system is allowed to irrigate 6 mm every 3 days or 12 mm every 6 days. Which one of the two approaches is the best?

Answer: Even if one knows the deficit, the irrigation system or the area of the fields impose some constraints. If we wait to irrigate until the software asks for it, we may have to irrigate all the fields at the same time. The cost of a system which would allow that could be too high compared to the advantages. Plants can tolerate a light stress: it will stimulate a deeper rooting system. Simulate three sites: one with irrigation of 6 mm every 3 days, another with irrigation of 12 mm every 6 days and one without irrigation. Run the software on the three sites and compare the number and the severity of the deficits and the costs of irrigation. The results of the analysis can be used as a guide for future years if they are based on many years of data.

With option 3 (irrigation), different irrigation frequencies can be simulated: e.g. every 3, 4 or 5 days. In each case, compare stress in terms of amplitude and length.

This technique can be used to evaluate all the decisions that were made during the growing season.

SITUATION 5: TO EVALUATE THE CHOICE OF A CROP

Question: The stress was enough to reduce yields. Would the situation have been different with a different crop? Was it a "normal" season?

Answer: Some crops are less sensitive to stress. Simulate another crop by using option 4 and see what would have been the results. By using the normals for the area provided with the software (annex C), one can know if the season was drier than usual.

SITUATION 6: MANAGEMENT OF FIELD OPERATIONS

Question: It has been rainy for the last week. However, return of sunshine is forecast. When will it be possible to plant or bring machinery into the field?

Answer: Suppose soil must be at 95% of its field capacity or lower in order to bring machines in the field without damaging the soil structure; then adjust the critical deficit to 5% and run the program with the forecast meteorological data. Then the column "Irrigation needed in" will in fact indicate when the soil will be dry enough to go into the field.

Note: all of these will only be reliable if the parameters have been well calibrated to the fields.

4. LIMITS OF "IRRIGATE"

In this version, crop coefficients are available for potatoes (default values) and corn. They can be modified and other crops can be added with option 4.

Some coefficients for the drainage have been fixed inside the program. For the present, they express the conditions for well-drained soils. On program execution the calculation starts on the date for which initial soil moisture has been provided. This date can be changed at any time by reinitializing the file (option 1) and by providing a new start date and new soil moisture conditions.

The software will auto-correct if soil moisture observations are provided. This means that measured values are substituted for estimates when computing soil moisture estimates for the next day.

A menu allows the user the choice of seven options. Option 1 (initialization) and 4 (crops) are required at least once, namely at the beginning of the season.

The software runs within any period of time from April 1st to October 31. The program outputs the plant available water in the whole profile and the deficit in the root zone as defined at the initialization stage. Root zones are the zones where the crop coefficient is greater than 0.

The addition of supplementary water by irrigation must be in mm. This software does not make any allowance for the type of irrigation system. Supplementary water can be measured by putting a rain gauge in the field at the time of the irrigation.

Soil moisture is printed out on the screen for a specific day, being the status of the soil at the end of each day and taking into account the occurrence of rain or irrigation, if any.

To rely on the results, it is strongly recommended to take soil moisture observations and do the required calibration under the conditions of use.

Each site is limited to five fields. A soil can be divided into a maximum of six zones. A plant can have a maximum of seven critical stages.

The potential evapotranspiration is estimated from maximum and minimum temperature. When the wind is moderate or strong (more than 20 km/hour), the actual evapotranspiration will be under-estimated if the soil is humid. Some preliminary tests have shown a difference of 2 mm/day at the most.

S E C O N D P A R T : H O W T O U S E P R O G R A M "IRRIGATE"

Part II of the document is divided in 2 sections. The first section explains some terminology and basic rules to know before starting to operate the software. The second section explains how to use the software, step by step.

Section 1.0: WHAT HAS TO BE KNOWN BEFORE STARTING?

VOCABULARY:

↵ : this symbol refers to the key which moves the cursor to the next line. Synonyms are: enter, return or CR

Date : the date is used in the software with the format: month, day (Mo/Day). When a date has to be provided to the software, each of the following formats are valid for May 3:

0503 or 503 or 5/03 or 05/03 or 5 03

Site and field: it is important to understand the difference between these two words. A field is a piece of land defined by a soil and a crop. A site refers to several fields, all under the influence of the same weather. Each site requires a set of files which contain the description of soil, plant and weather of one or more fields. A new site name must be used if different weather data are to be input.

TO START THE SOFTWARE:

Start up computer as usual. When A> is displayed, insert the diskette which contains the software in drive A. Then type:

IRRIGATE

and a menu will be displayed.

For users with a hard disk (drive C), copy the diskette into it. A sub-directory can be used (See DOS manual). Execution of the program will be faster.

TO PRINT WHAT APPEARS ON THE SCREEN:

The printing of the screen can be done by using the special combination keys of the IBM-PC.

Ctrl + PrtSc : print on the screen and on paper at the same time

Shift + PrtSc : print the actual content of the screen on paper

TO END THE EXECUTION OF THE PROGRAM:

Hit ↵ to any question being displayed until you get: A>
or hit together the 2 keys Crtl + Break. In the last case, it may happen that some newly entered data will not be saved.

Section 2.0: HOW TO USE "IRRIGATE" STEPWISE

The software is provided on a diskette which also contains an example. That example was used for the demonstrations that will be presented in the next few pages. To run the program, put the diskette into the disk drive and type:

A> IRRIGATE ↵

The program will answer by displaying:

```
        IRRIGATE

Land Resource Research Centre
Agriculture Canada
31 May 1989
```

Then screen is cleared and the following question is asked:

```
Site name:
```

In order to follow the example, type FARMSITE. Otherwise, enter the name choosen for the site. If the site doesn't exist yet, then the program will create the necessary files.

The following message will appear if a normal data file with mean daily maximum and minimum air temperatures is not yet available:

```
Normal data file has not been defined.  No forecast available
```

To get a forecast for the next irrigation, it is necessary that the program has access to a normal data file. Such files are available for the official climatological stations listed in annex C. Select the name of the nearest station, choose option 0 at the next step and give its file name to the program. The normal data file is also used to calculate the daily potential evapotranspiration.

Then the main menu will be displayed:

```
                OPTION          DESCRIPTION
                ------          -----------
                   0     NORMAL DATA file creation
                   1     FIELDS Information
                   2     METEOROLOGICAL Data
                   3     IRRIGATION Data
                   4     CROP Information
                   5     OBSERVED SOIL MOISTURE Data
                   6     Optional data
                   7     SOIL MOISTURE BUDGET

To exit, hit ↵
To change site, type its name
-------------------------------------------------------------
OPTION for site FARMSITE:
```

From the menu, choose the option of interest:

0: this option appears only if the normals data file has not been defined.

1: to define field characteristics at the start of the season or to modify these at any time.

2: to enter meteorological data (actual, forecast or estimated).

3: if an irrigation has been done, to enter the amount in mm.

4: to define crops, update stage observations and select crop coefficients.

5: to enter any soil moisture observations that are available.

6: to note supplemental observations.

7: to run the budget.

↵ : to end and return to DOS.

To change from one site to another (one place to another or one year to another) type its name. Then the main menu will appear again but the site will not be the same.

In the following pages, each option will be discussed.
Type 0 to get the display of the next page.

OPTION 0: NORMAL DATA File creation

In order to get a good estimation of the potential evapotranspiration and to get the most advice from the software, it is important to provide normals data to "IRRIGATE".

Only one question will be asked and it is the name of the file where normals data can be found. Look in annex C, to find the name of the nearest station. Put the diskette with the normals file into drive B.

(Use drive A if no drive B is available and replace B: by A:)

```
Name of the normal data file  B:Q01CAPLAN
Please wait
```

Then "IRRIGATE" will return to the main menu and option 0 will not be displayed anymore but will remain available.

If one hits ↵ or types the name of the actual site, "IRRIGATE" returns to the main menu and no normal data file will be defined.

Choose option 1 to get the display of the next page.

OPTION 1: FIELD DEFINITION AND INFORMATION

It is necessary to provide the program with information relative to the farm management and to define soil properties for each field.

```
                FIELDS INFORMATION FOR SITE FARMSITE

Hit ↵  to keep the previous value

YEAR :  1987 ? ↵
NUMBER OF FIELDS TO BE MANAGED:  2 ?
```

The year is only used as information when results are displayed.

The number of fields refers to the number that will be managed with the same meteorological data. When there is more than one field, a menu will then be displayed.

```
Site FARMSITE
-------------------------------------------------------------

      FIELD NUMBER                FIELD NAME
      ------------                ----------
           1                      Jones
           2                      Simard

To change site, type its file name.
-------------------------------------------------------------


FIELD NUMBER ( ↵  return to menu): ? 1 ↵
```

Type the field number followed by ↵ . The site can be changed by typing its name. Then the software will start over from the question YEAR?

```
NAME OF THE FIELD # 1 : Jones?
```

The name of a field is not used by the software. It is information for the user only. Change the name by typing the new name or hit ↵ to keep it as it is.

```
NUMBER OF ZONES IN THE PROFILE OF FIELD # 1 : 1 ?
```

It is necessary to define at least one zone which should be the maximum thickness of the soil where the roots are. It can be wise to subdivide that zone into several zones if:

- the soil structure changes in the root zone
- the root zone is deep (more than 30 cm)
- the soil is poorly drained

The root zone is the maximum depth to which roots will penetrate by the end of the growing season. The subdivision of that zone into several zones allows for better control of the water to be added by irrigation. A soil may contain enough water but the plant may not yet have roots at that depth to use the water. However, too much irrigation can inhibit the development of the root system.

When only one zone is defined, the software assumes that all the water from the rain or the irrigation enters into that zone on that day. If a certain number of layers drained in one day are defined, the water will drain progressively through the profile. This is not required in all types of soil.

If the soil is poorly drained and the water in fact takes more than one day to enter the soil, then at least 2 zones should be defined. If so, the following question will be asked:

```
HOW MANY ZONES ARE DRAINED IN ONE DAY: 1 ?
```

This question will appear only if there is more than one zone in the profile of the field. If the user changes the number of zones, the previously entered observed soil moisture data should be re-entered with option 5. Crop coefficients will also have to be reviewed with option 4. The following message will appear:

```
NUMBER OF ZONES IN THE PROFILE OF FIELD #1: 1 ? 2 ↵
Crop coefficients and observed soil moisture data already entered
will be affected by this change..!
Check with option 4 and 5

HOW MANY ZONES ARE DRAINED IN 1 DAY: 1 ?
```

The user is then asked to enter the date on which the soil moisture budget must begin. Meteorological data must start on or before this date.

```
DATE TO START THE BUDGET (Mo/Day):  6/05?
```

It is necessary to provide an initial soil moisture value on the starting date. To estimate it, the date may be set on the day after a major rain occurred and the value be fixed at the field capacity. Meteorological data must be provided from or before this date.

The user is then asked to enter the following soil characteristics for the whole profile (or for Zone 1 if there is more than one zone).

```
SOIL CHARACTERISTICS FOR THE WHOLE PROFILE
SATURATION (%)              : 25 ? ↵
FIELD CAPACITY (%)          : 24 ? ↵
PERMANENT WILTING POINT(%): 10 ? ↵
DEPTH (cm)                  : 25 ?
```

The four questions above refer to the characteristics of the profile (or each zone if there is more than one). These values should be provided in volumetric (cm^3 of water per cm^3 of soil). However, gravimetric values (g of water per g of soil) can also be given if bulk density or volume of soil sampling are not available. If gravimetric values are used, then bulk density is assumed to be 1; the effect will be that the software will overestimate the actual deficit by a fraction directly related to the real bulk density. Figure 1 (first part, section 2.2.1) can be used to estimate these.

The important point is to be consistent and always use the same units.

Saturation can be estimated by using the observed soil moisture after a major rain when water is almost forming in puddles on the surface. Field capacity can be estimated by using the same value, 24 hours after the rain. Permanent wilting point can be estimated by using figure 1 (see First Part, section 2.2.1) Observed data can be used to adjust these more precisely.

Depth is the distance from the surface to the bottom of the specified zone. Thus when two or more zones are defined, the depth of the lower zone must be greater than the previous one.

At this point, the user is asked to enter the initial soil moisture content in the whole profile (or in Zone 1 if there is more than one zone) on the date budgeting is to begin. The value can be measured or estimated.

```
INITIAL SOIL MOISTURE ON June 05: 19.5 ?
```

Soils can restrict availability of water to roots by affecting water movement. The Soil Parameter takes this effect into account. Experience has shown that a value of 1.0 is usually acceptable in most cultivated soils and in light soils.

```
SOIL PARAMETER

Soil texture          Suggested value
------------          ---------------

SANDY                      1.00
LOAMY                      0.75
CLAY                       0.25

PARAMETER VALUE:  1?
```

At this point, the user is asked to enter soil characteristics for the next zone if there is more than one zone in the profile.

When all zones are completed, the program asks for:

```
Percent of drainage/runoff:  80 % ?
```

This factor is used to quantify the runoff and drainage properties of the soil. A value of 100% means that when the water added to the soil by irrigation or rain is above the value at Saturation, then the excess water will be runoff or be drained out of the root zone in the same day. A value of 0% means that there will be no runoff and the excess water will remain at the surface for one or more days before penetrating into the soil. The value can be adjusted from visual observations and by trying different values of the drainage/runoff coefficient.

The effect of this parameter is apparent only when there is excess water.

Choose option 2 from the main menu to get the display on the next page.

OPTION 2: UPDATE OF THE METEOROLOGICAL DATA

This option is chosen to enter daily meteorological data. Forecast data or estimated data can be entered. There should be no missing data; as the software doesn't check if all the data are there, in such cases, results are unpredictable.

```
                UPDATING METEOROLOGICAL DATA AT SITE

  Site:  farmsite

  Hit N to use normal data file.

  Hit * to get a listing
  Hit ↵  to keep the previous value

  Last date is June 16
  DATE (Mo/Day) (<·> return to menu)   6/17?
```

The date displayed is the next day for which meteorological data has to be entered. Hit ↵ to insert meteorological data for that day.

```
  MAX TEMP. ( 0 ): ? 20↵
  MIN TEMP. ( 0 ): ? 10↵
  RAIN ( 0  mm) : ?↵

  PET calculated:   3.5
```

If the normal data file has not been defined (see option 0), the following message will appear:

```
  PET is under-estimated; please provide the normal data file
  with option 0.
```

This means that the potential evapotranspiration used by "IRRIGATE" is lower than the real value.

No data will be recorded if maximum and minimum temperatures are both zero.

```
DATE (Mo/Day) (<-> return to menu)   6/18? ↵

MAX TEMP. ( 0 ): ? ↵
MIN TEMP. ( 0 ): ? ↵

DATE (Mo/Day) (<-> return to menu)   6/18?
```

It is possible to see the data already entered by typing the date and see just one day at a time.

```
DATE (Mo/Day) (<-> return to menu)   6/18? 6/12 ↵

MAX TEMP. ( 21 ): ? ↵
MIN TEMP. ( 4.5 ): ? ↵
RAIN ( 4  mm) : ? ↵

PET calculated:   4.6

DATE (Mo/Day) (<-> return to menu)   6/13?
```

One can indicate if the meteorological data entered are estimated (from the forecast, for example). To do so, just type the letter e or E after typing the value.

```
DATE (Mo/Day) (<-> return to menu) 6/13 ? 6/12 ↵

MAX.TEMP ( 21 ) : ? 20e ↵
MIN.TEMP ( 4.5   ) : ? ↵
RAIN ( 0 mm  ) : ? 4e  ↵
PET calculated : 4.6 E
```

So for June 12, maximum temperature and precipitation are estimated values. Estimated values are treated like any other value by the software but they are followed by the letter "E".

The letter N can be typed instead of the temperature. In that case, the normal temperature for that day will be used. This option can be used when the forecast is for seasonal temperatures.

```
DATE (Mo/Day) (<·>return to menu)  6/13?↵

MAX TEMP. ( 20.5  ): ? n ↵
MIN TEMP. ( 4.5  ): ? ↵
RAIN ( 0 mm ): ? ↵
PET calculated:  4.9 E
```

If one type N instead of the date, the maximum and minimum temperatures will be the normal temperatures for that day.

```
DATE (Mo/Day) (<·> return to menu)  6/13? n ↵

Normal temperature data will be used.
```

There is no normal available for precipitation. When displayed, normals appear followed by the letter E.

```
DATE (Mo/Day)  (<·> return to menu) 6/14? ↵

MAX TEMP. ( 22.1 E): ? ↵
MIN TEMP. ( 8.8 E): ? ↵
RAIN ( 0 mm E): ? ↵
PET calculated: 4.3 E
```

It is also possible to see all the data entered by typing *.

```
DATE (Mo/Day) (<·> return to menu)   6/18?  * ↵

DATE   T.MAX     T.MIN     PREC      PET

6/14   26.0       5.5      12.0      5.9
6/15   20.0       6.0       0.0      4.1
6/16   19.5       6.0       0.0      4.0
6/17   20.0      10.0       0.0      3.5

END OF DISPLAY
Hit ↵
DATE (Mo/Day) (< > return to menu)   6/18?  .
```

To change from one site to another, type its name instead of the date.

```
DATE (Mo/Day) (<·> return to menu)  6/8?  Test UPDATING ....

Hit * to get a listing
Hit ↵  to keep the previous value

Last date is New file
DATE (Mo/day) (<·> return to menu)  4/01?
```

To exit from this option, type a period (.) instead of a date.
Choose option 3 from the main menu to get the display of the next page.

When meteorological data are available on ASCII files, use the software CONVERT instead of entering all the data manually.

OPTION 3: INPUT OF IRRIGATION AMOUNT

This option is chosen every time an irrigation is done or simulated.

```
                        IRRIGATION DATA

Site FARMSITE
-------------------------------------------------------------

        FIELD NUMBER                    FIELD NAME
        ------------                    ----------
             1                          Jones
             2                          Simard

To change site, type its file name .
-------------------------------------------------------------

FIELD NUMBER ( ↵  return to menu): ? 1 ↵
```

Give the number of the field to update data for that field. Hit ↵ to exit that option and return to the menu. It is also possible to type the name of another site: the fields of that new site will be displayed.

```
 FIELD # 1 : Jones

Hit * to get a listing
Hit ↵  to keep the previous value

DATE OF IRRIGATION (Mo/Day): ?
```

Irrigation data are entered by giving the date (mo/day) and the amount of water in mm.

```
DATE OF IRRIGATION (Mo/Day): ? 6/16 ↵
Amount   6.0 mm ? 0 ↵
DATE OF IRRIGATION (Mo/Day): ? 6/16 ↵
Amount   0.0 mm ? 6 ↵
DATE OF IRRIGATION (Mo/Day): ?
```

Any amount of water can be added or changed by typing the corresponding date.

The amount of water is in mm. The value should be measured by placing a rain gauge in the field.

If rainfall is different from one field to another, the differences that are not taken into account by the meteorological data can be inserted as irrigation. The software doesn't make any distinction between rain water or irrigation water.

To get the listing of the previous value, type * followed by

```
DATE OF IRRIGATION (Mo/Day): ? * ↵

DATE          AMOUNT
Mo/Day          (mm)

 6/16           6
```

To return to the main menu, hit ↵ when the date and when the number of the field are requested.

Choose option 4 from the main menu to get the display on the next page.

OPTION 4: INFORMATION ON THE CROPS

This option allows the user to define the crops, to update date of occurence of some phenological events and to set or change crop coefficients. At least one stage has to be defined. More than one harvest date can be introduced.

```
                    CROP INFORMATION

Site FARMSITE
-------------------------------------------------------------

      FIELD NUMBER                  FIELD NAME
      ------------                  ----------
           1                        Jones
           2                        Simard

To change site, type its file name .
-------------------------------------------------------------

FIELD NUMBER ( ↵ return to menu): ? 1 ↵
```

Give the number of the field to update data for that field. Hit to exit that option and return to the menu. It is also possible to type the name of another site: the fields of that new site will be displayed.

```
CROP CHOICE:

1. POTATO
2. CORN
3. STRAWBERRY
4. CEREALS
5. Other crops

CHOICE:  Potato ? 1 ↵

Number of stages (max: 7)?
```

If the crop stage has already been defined, just hit ↵ instead of giving a choice. When a choice is selected, all the previous phenological stage names and dates are reset to the default values.

Then a table of the crop coefficients is printed. This table can be printed also by typing * at any of the first two questions (critical deficit and stage number).

```
Crop coefficients for Potato are:

STAGE    NAME                          DATE  COEFFICIENTS BY ZONE
  1      PLANTING                      5/15          0.4
  2      10% EMERGENCE                 6/15          0.5
  3      10% BUDS                      7/01          1.0
  4      TUBERISATION or 10% FLowering 7/15          1.1
  5      90% Flowering                 8/01          1.0
  6      SENESCENCE or Topkill         8/20          0.6
  7      HARVEST                       9/15          0.4
CRITICAL DEFICIT IS 35%
```

If more than one zone has been selected from the profile, crop coefficients are listed for each zone.

```
                        UPDATING
                        --------

 FIELD # 1 : Jones

 Hit * to get a listing
 Hit      to keep the previous value

 Critical deficit is  35 % ?
```

Critical deficit can be based on the amount of available water left in the soil for the plant or on the capacity of the irrigation system.

When the critical deficit is exceeded, the software advises irrigation. A critical deficit of 35% means that the available water in the profile is at 65 % of the maximum possible. If the maximum available water is 50 mm, it means that when the remaining available water is 32.5 mm, the plant will start to suffer from stress. Usually the value of the critical deficit ranges from 35% to 50% of the maximum available water depending of the soil properties and the plant sensitivity.

Type any of these three possibilities: new value between 0 and 100% or to keep the previous value or * to get the table of the crop coefficients.

```
STAGE NO (Hit ↵  to end): ? 1 ↵
NAME: PLANTING? ↵
DATE (Mo/Day)  5/15? ↵
COEFFICIENTS :  .4 ? ↵

STAGE NO (Hit ↵  to end): ?
```

To modify the name of a stage, its date of occurrence or the crop coefficient, enter the number of the stage and answer the three questions that follow. If there is more than one zone, a coefficient for each zone will be asked. Hit ↵ to keep any previous value or type the new value followed by ↵ .

If the profile contains only one zone, crop coefficients for potatoes are used in the program. These crop coefficients have been tested in St-Alban, near Quebec in 1985. The correlation was 89% between observed and measured soil moisture. However, if the soil is divided into additional zones, one must define a coefficient for each zone. These are some suggestions on how to do so:

--> crop coefficient = 0 if no roots in the zone
--> for each stage, sum of the coefficients should be equal to the value suggested for one zone.

Type * to get the table of the crop coefficients or hit ↵ to return to the fields menu.

Choose option 5 from the main menu to get the display on the next page.

OPTION 5: INPUT OF OBSERVED SOIL MOISTURE DATA

This option is chosen when observed soil moisture data are available. The software will use these data to correct itself, i.e. the estimated value will be replaced by the observed value for computing the next day's soil moisture.

```
            OBSERVED SOIL MOISTURE DATA

Site FARMSITE
-------------------------------------------------------------

      FIELD NUMBER                FIELD NAME
      ------------                ----------
           1                      Jones
           2                      Simard

To change site, type its file name .
-------------------------------------------------------------

FIELD NUMBER ( ↵ return to menu): ? 1 ↵
```

Type the number of the fields where measurements were done or hit to return to the main menu. The name of another site can also be typed.

```
 FIELD # 1 : Jones

Hit * to get a listing
Hit ↵ to keep the previous value

DATE (Mo/Day) or ↵ to return to menu: ?
```

A value can be modified or inserted by typing its date.

```
DATE (Mo/Day) or ↵ to return to menu: ? 6/12 ↵
SOIL MOISTURE DATA: 19.7%
(Type 0 to cancel previous value)? 0 ↵
DATE (Mo/Day) or ↵ to return to menu: ? 6/12
SOIL MOISTURE DATA: no observation
? 19.7 ↵
DATE (Mo/Day) or ↵ to return to menu: ?
```

Cancellation of a previous value deletes the observation date.

If there is more than one zone in the profile, the user must insert measured values for each zone. Previous values can be retained by hitting ↵ each time soil moisture data are requested.

```
DATE (Mo/Day) OR ↵ to return to menu? 7/09 ↵
ZONE NUMBER OR ↵ TO END? 1 ↵
SOIL MOISTURE DATA: 13.0%
(Type 0 to cancel previous value)? ↵
ZONE NUMBER or ↵ to end? 2 ↵
SOIL MOISTURE DATA: 10.5%
(Type 0 to cancel previous value)? ↵
ZONE NUMBER or ↵ to end? ↵
 DATE (Mo/Day) or ↵ to return to menu?
```

A listing of the values already entered can be obtained by typing * followed by ↵ . If there is more than one zone in the profile, measured values will be displayed for each zone.

```
DATE (Mo/Day) or ↵ to return to menu: ? *

DATE          MEASURED VALUES (%)
----          -------------------

6/12                19.7

END OF DISPLAY.
Hit ↵

DATE (Mo/Day) or ↵ to return to menu: ?
```

Hit ↵ to return to the menu of the fields.

Choose option 6 from the main menu to get the display on the next page.

OPTION 6: SUPPLEMENTARY INFORMATION

This option permits entry of miscellaneous information. Each piece of information is inserted with a date. The software doesn't use the information; it is used as a notebook.

One can note observations related to the crop development or other phenomena. For example:

- appearance of insects
- appearance of disease
- significant phenological stages
- rooting depth at different times of the season
- percentage of soil cover at different times
- hail, violent storm, winds, frost, etc.
- anything that can help to interpret the results

```
Site Farmsite

*   : listing of the information available
↵   : return to main menu

Date (Mo/day): ?
```

Type the date for which an event should be recorded.

```
Date (Mo/Day):  07/02 ↵

Note: do not use comma

? spray for potato blight ↵
```

Each record of information has 70 characters. The date is the one for which the remark is applicable. To modify information, type its date. This is one record per day.

```
Date (Mo/Day): ?  07/02 ↵

Spray for potatoe blight
(Type 0 to cancel,  ↵  to retain information)

Note: do not use comma

? Spray BRAVO 500 21 for potato blight ↵
```

The option * lists all the information already inserted into the file. It returns to the option 6 menu.

```
Date (Mo/Day): ? * ↵

07/02 --  Spray Bravo 500 21 for potato blight

Hit ↵

Date (Mo/Day): ?
```

Return to the main menu by hiting ↵ instead of a date.

Choose option 7 to get the display on the next page.

OPTION 7: RUN AND DISPLAY SOIL MOISTURE BUDGET

This option give the status of the water in the soil. If the normal data file has been defined, it will give a forecast of when the next irrigation is required. However, that forecast, based on normal temperature data, assumes that there is no rain expected for the following days.

```
                    SOIL MOISTURE BUDGET

Site FARMSITE
-------------------------------------------------------------

          FIELD NUMBER                    FIELD NAME
          ------------                    ----------
               1                          Jones
               2                          Simard

To change site, type its file name .
-------------------------------------------------------------


FIELD NUMBER ( ↵  return to menu): ? 1 ↵
```

Choose the number of the field for which the budget is needed. Hit to return to main menu. The name of a new site can also be typed.

```
DATE TO START PRINTING (Mo/Day or  ↵  if June 06) : ? ↵
DATE TO END PRINTING (Mo/Day or  ↵  if June 17):? ↵
Output on paper (y/N) N:?
```

The software always calculates the budget starting on the initial date defined with option 1 and ending on the last date for which meteorological data are available. The display of the budget can be started and stopped at any date after that starting date and before the last date.

```
                SOIL MOISTURE BUDGET  1987

FIELD # 1 : Jones
MAXIMUM AVAILABLE WATER:  35.0 mm
INITIAL AVAILABLE WATER:  23.8 mm      on June 05
  *CRITICAL DEFICIT*   :  12.3 mm
```

Critical deficit refers to root zones. If there is more than one zone, the critical deficit for the root zones will be displayed as:

```
*CRITICAL DEFICIT*:  12.3 mm to 28.0 mm varying with stage
```

The critical deficit in mm is calculated from the one defined with option 4:

Critical deficit (%) x maximum available water content.

Data printed are:

- maximum available water content in mm
- initial available water content in mm; this is the value used to start the budget
- critical deficit: the value of the deficit at which the plant has stress. The program calls for irrigation when the deficit reaches this value.
- if there is more than one zone, the critical deficit is the one in the root zone.

```
**********************************************************************
DATE   STAGE  INPUT   SOIL     DEFICIT          IRRIGATION    DEMAND
Mo/Da   NO    WATER   WATER                     NEEDED IN     FOR WATER
----------------------------------------------------------------------
6/06     1    0.0 mm  19.0 %   12.6 mm (36%)-   0  Days      Normal
6/07     1    3.0 mm  19.6 %   10.9 mm (31%)    1  Days      Normal
6/08     1    0.0 mm  19.2 %   12.1 mm (35%)    1  Days      Normal
6/09     1    0.0 mm  18.8 %   13.1 mm (37%)-   0  Days      Normal
6/10     1    0.0 mm  18.3 %   14.2 mm (41%)-   0  Days      Below
6/11     1    3.0 mm  18.7 %   13.3 mm (38%)-   0  Days      Above
6/12     1    4.0 mm  19.7 %   10.7 mm (31%)    1  Days      Normal
OBSERVED SOIL WATER:  19.7 %
6/13     1    0.0 mm  19.1 %   12.3 mm (35%)-   0  Days      Normal
6/14     1   12.0 mm  23.1 %    2.2 mm ( 6%)    5  Days      Above
6/15     2    0.0 mm  22.4 %    4.1 mm (12%)    4  Days      Normal

Hit ↵ to continue or <·> to end.
```

For every day, the following results are printed:

- date (Mo/Da): date for which results are valid. Letter "e" will appear if estimated meteorological data have been used. Letter "i" will appear if irrigation was recorded for that date.

- stage no : actual phenological stage as defined with option 4

- input water: amount of water supplied by irrigation or by rain

- soil water : estimated water content in the root zones in % by weight or by volume. A "+" means the soil is above field capacity and record appears in blue.

- deficit: amount of water required to bring the root zone up to field capacity. A "-" indicates that the plant has stress and the deficit exceeds the critical value; record is in red. Where the soil is divided in 2 zones or more, it is possible that the deficit changes abruptly when a new stage is reached.

- forecast of when next irrigations is needed based on mean daily maximum and minimum temperature values stored on file FARMSITE.NOR. The program calculates the number of days before the soil reaches the critical deficit, assuming there will be no rain and no irrigation.

- demand for water: the actual daily need for water by the plant is above, below or normal compared to the normal daily demand.

```
DISPLAY THE DIFFERENCES BETWEEN OBSERVED AND MEASURED VALUES (Y/n)? Y
Date Stage  Difference in % (observed-estimated)

612  1      0.0

END OF DISPLAY.
Hit ←'
```

If observed soil moisture data are available, the difference between observation and estimation by the program are printed. The software returns to the menu of the fields.

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ANNEX A: GLOSSARY

AVAILABLE WATER (mm): the amount of soil water within the root zone of the crop that is available to the crop. It is determined by subtracting the amount of water held in the soil at the permanent wilting point from the soil water content at field capacity to the depth of the root zone.

BULK DENSITY (g/cm3): the ratio between the mass of a dry soil sampling and its volume.

CRITICAL DEFICIT: the value of the deficit at which the crop starts to suffer from stress. It is expressed in mm of water or in terms of a percentage of the maximum available water.

CROP COEFFICIENT: the fraction of the PET that can be extracted from a soil zone by the roots.

DEFICIT: the amount of water required to bring the root zone up to field capacity.

DEPTH (cm): the distance from the surface to the bottom of a particular soil zone.

DRAINAGE AND RUNOFF COEFFICIENT: when soil moisture is above field capacity, this is the fraction of rain lost by runoff, drainage or evaporation.

FIELD CAPACITY (%): water content of the soil 2 or 3 days after the soil has been saturated and drainage has practically ceased. The percentage may be expressed in terms of weight or volume. It is also the water contained in a soil after applying a pressure of 1/3 bar.

MAXIMUM AVAILABLE WATER (mm): the amount of water held in the soil between field capacity and permanent wilting point over a zone or the whole profile.

PERMANENT WILTING POINT (%): water content of the soil, expressed as percentage by weight or by volume, at which plants wilt and fail to recover their turgidity when placed in a dark , humid atmosphere. It is commonly estimated by applying a pressure of 15 bars.

POTENTIAL EVAPOTRANSPIRATION (PET) (mm): amount of water evaporated and transpired by a full canopy well watered.

ROOT ZONE: thickness of the profile which contains the roots. Can refer to one or more zones.

SATURATION (%): water content of the soil, expressed as percentage by weight or by volume, when all the voids between soil particles are filled with water.

SOIL MOISTURE MEASUREMENT BASED ON VOLUME (cm3/cm3): there are two ways to get the % soil moisture on a volumetric basis:

% water (cm3/cm3)= % water (g/g) x bulk density

$$\% \text{ water (cm3/cm3)} = \frac{\text{(weight of moist soil-weight of dry soil)}}{\text{volume of soil sampling}} \times 100$$

SOIL MOISTURE MEASUREMENT BASED ON WEIGHT (g/g): An approximation of the percentage of water in the soil can be obtained by drying and weighing soil samples and by doing the calculation:

$$\% \text{ water (g/g)} = \frac{\text{weight moist soil - weight of dry soil}}{\text{weight dry soil-weight of container}} \times 100$$

SOIL WATER (%): the amount of water in the soil at any given time including water not available to the plant expressed as a percentage by weight or by volume.

ZONE: a layer of soil with a specific thickness inside the whole profile.

ANNEX B: ERROR MESSAGES

Crop coefficients and observed soil moisture data already entered will be affected by this change..!
Check with option 4 and 5
**Action: The number of zones has been changed. Crop coefficients are defined based on zones and may not be right anymore. Check with option 4. Observed soil moisture data are also based on zones and can be incorrect. Check with option 5.

DEFINE CROPS WITH OPTION 4
**Action: Some options cannot be selected if soils (option 1) and crops (option 4) have not been defined yet. Define crops with option 4.

Do you want to change from site ?? to site ? (y/N)?
**Action: the name of the site seems to be ambiguous. The software is asking for a confirmation.

Empty file
**Action: no supplementary information has been recorded yet with option 6.

ERROR: check date of stage
**Action: check with option 4 if all the stages have a valid date. Each stage must have a date and this date can be estimated if not known yet.

ERROR: date must be after 04/01
ERROR: date must be before 10/31
**Action: the software runs from April 1st to October 31st. To change these dates, modify the source of the program (annex D).

ERROR: Depth should be greater than xx cm
**Action: When two or more zones are defined, the bottom of the lower zone must reach a depth greater than the previous zone. Zones are described in terms of depth from the surface to the bottom of the zone rather than thickness.

ERROR: ENDING DATE SMALLER THAN STARTING DATE
**Action: Check the date entered. Soil moisture budget can be printed only between the date for which an initial soil moisture value was provided (option 1) and the last date for which meteorological data are available.

ERROR: Field capacity must be lower than saturation
**Action: Reenter saturation value. It must be greater than field capacity and it is the maximum possible soil moisture value calculated by the software.

Error in file: ?.INI
Is BASIC configured to open 4 files at the same time?
**Action: An error was detected at the initialisation (option 1). Check if 4 files can be opened at the same time. This could occur with BASICA and then can be corrected by typing:

BASICA/F:4 IRRIGATE

ERROR IN FILE: ?.IRR
**Action: An error was detected when opening the irrigation file. Check the name of the site

ERROR IN FILE: ?.PHE
**Action: An error was detected when opening the phenological file. Check the name of the site

ERROR ON GLOBAL RADIATION
**Action: Value of global radiation is negative or greater than 1200 g-cal/cm^2/day. PET value is under-estimated. Provide reliable normal data file with option 0 or use software CONVERT.

ERROR: Max temp must be greater than Min temp
**Action: Check the temperatures. Maximum temperature must be greater than the minimum temperature.

ERROR: Permanent wilting point must be lower than field capacity
**Action: Verify both values and reenter field capacity and permanent wilting point. The latter is the minimum soil moisture value calculated by the software.

INITIALIZE WITH OPTION 1
**Action: Some options cannot be selected if soils (option 1) and crops (option 4) have not been defined yet. Define fields and soils by using option 1.

Invalid Option
**Action: To choose an option enter a number between 0 and 7.

MAXIMUM FIELDS ALLOWED:
**Action: restrict the number of fields for the site. Either create another site or modify the source of the program (annex D)

MAXIMUM FIELD NUMBER ALLOWED:
**Action: you tried to access a field that was not defined with option 1. Check the field number or define it.

Normal data file has not been defined. No forecast available
**Action: Irrigation forecasts are based on mean temperature stored in the normal data file. To get these forecasts, define the normal data file with option 0.

Normal data file is missing.
Date of next irrigation will not be displayed
**Action: find the nearest climatological station in Annex C and use option 0.

Provide normal data file.
**Action: Provide the normal data file with option 0. That file includes solar radiation value at the top of the atmosphere which is used to calculate the PET. Value of PET is under-estimated.

This file is empty.
**Action: The normal data file name is wrong or is on another drive. Check the name: it may require the extension .NOR

ANNEX C: LIST OF AVAILABLE CLIMATOLOGICAL STATIONS

QUEBEC: 1974-1984

Name of file	Name of station	Number	Latitude	Region
Q01CAPLA	CAPLAN	7051120	48.10	1
Q01AMQUI	AMQUI	7050140	48.51	1
Q01NDULA	N.D.DU LAC	7055675	47.61	1
Q01LAPOC	LA POCATIERE	7054095	47.35	1
Q01MONTJ	MONT-JOLI	7055120	48.61	1
Q01TPIST	T PISTOLES	7058560	48.15	1
Q01STARS	ST ARSENE	7056890	47.93	1
Q01LADRI	LADRIERE	705LG09	48.25	1
Q01STCLE	ST-CLEMENT	7057024	47.91	1
Q01BDSAB	B D SABLES	7050MM5	48.71	1
Q01STGAB	ST GABRIEL	7057269	48.48	1
Q02STAUG	ST AUGUSTIN	7016900	46.73	2
Q02DESCH	DESCHAMBAULT	7011982	46.66	2
Q02QUEBE	QUEBEC A	7016294	46.80	2
Q02MONTM	MONTMAGNY	7055210	46.96	2
Q02STECA	SE CATHERINE	7016932	46.85	2
Q02STFRA	ST-FRANCOIS	704GBFF	46.98	2
Q02BAIES	BAIE ST-PAUL	7040446	47.43	2
Q02STFLA	ST-FLAVIEN	7027259	46.48	2
Q02STALB	ST-ALBAN	7016800	46.71	2
Q02LASAB	L A SABLES	701LEEH	46.86	2
Q02STMIC	ST-MICHEL	7057567	46.83	2
Q02BEAUS	BEAUSEJOUR	7020567	46.66	2
Q02CHATR	CHATO RICHER	7041330	46.96	2
Q03FRAMP	FRAMPTON	7022553	46.43	3
Q03STPRO	ST-PROSPER	7027660	46.21	3
Q03STEPH	ST-EPHREM	7027200	46.06	3
Q03SCOTT	SCOTT	7027840	46.50	3
Q04NICOL	NICOLET	7025440	46.21	4
Q04STGUI	ST-GUILLAUME	7027302	45.88	4
Q04VICTO	VICTORIAVILL	7028720	46.05	4
Q04STWEN	ST-WENCESLAS	7027783	46.16	4
Q04PIERR	PIERREVILLE	7026043	46.08	4
Q05LENNO	LENNOXVILLE	7024280	45.36	5
Q05SHERB	SHERBROOKE	7028124	45.43	5
Q05BROME	BROME	7020840	45.18	5
Q05COATI	COATICOOK	7021840	45.15	5
Q05RICHM	RICHMOND	7026465	45.63	5
Q05BISHO	BISHOPTON	7020800	45.58	5
Q06STHYA	ST-HYACINTHE	7027361	45.61	6
Q06STHUB	ST-HUBERT	7027320	45.51	6
Q06FARNH	FARNHAM	7022320	45.30	6
Q06ROUGE	ROUGEMENT	7026700	45.43	6
Q06STNAZ	ST-NAZAIRE	7027588	45.75	6
Q06SABRE	SABREVOIS	7026734	45.21	6
Q06STAMA	ST-AMABLE	7026818	45.66	6
Q06MARIE	MARIEVILLE	7024627	45.41	6

Name of file	Name of station	Number	Latitude	Region
Q06FLEUR	FLEURY	7022375	45.80	6
Q06STEMA	SE-MADELEINE	7027517	45.61	6
Q07STEMA	STE-MARTINE	7027540	45.25	7
Q07COTDU	COTO DU LAC	7011947	45.31	7
Q07STANI	ST-ANICET	7026836	45.13	7
Q07STECL	SE-CLOTHILDE	7027040	45.21	7
Q07STBER	ST-BERNARD	7026916	45.01	7
Q07HUNTI	HUNTINGDON	7023240	45.05	7
Q08LACHU	LACHUTE	7033650	45.65	8
Q08SHAWV	SHAWVILLE	7038040	45.60	8
Q08WAKEF	WAKEFIELD	7038835	45.60	8
Q08SHEEN	SHEENBORE	7038080	45.96	8
Q08PETAW	PETAWAWA	6106398	45.95	8
Q08ANGER	ANGERS	7030170	45.55	8
Q08NDPAI	N.D. PAIX	7035666	45.81	8
Q08CHART	CHARTERIS	7031315	45.70	8
Q08LUSKV	LUSKVILLE	7034365	45.53	8
Q08MONTE	MONTEBELLO	7035109	45.65	8
Q08MONTL	MONT-LAURIER	7035160	46.55	8
Q08MANIW	MANIWAKI	7034480	46.38	8
Q08NOMIN	NOMININGUE	7035520	46.38	8
Q09VILLE	VILLE-MARIE	7088760	47.40	9
Q09AMOS	AMOS	7090120	48.56	9
Q09LASAR	LA SARRE	7094120	48.78	9
Q09REMIG	REMIGNY	7086460	47.75	9
Q09VALDO	VAL D'OR	7098600	48.06	9
Q09EARLT	EARLTON	6072225	47.70	9
Q10LASSO	L'ASSOMPTION	7014160	45.81	10
Q10STBEN	ST-BENOIT	7016906	45.56	10
Q10STJAC	ST-JACQUES	7017380	45.96	10
Q10BERTH	BERTHIERVILL	7010720	46.05	10
Q10STEBE	STE-BEATRIX	7016902	46.20	10
Q10MONTR	MONTREAL INT	7025250	45.46	10
Q10MIRAB	MIRABEL	7035290	45.68	10
Q10STEEL	SE-ELIZABETH	7017148	46.06	10
Q11STNAR	ST-NARCISSE	7017585	46.53	11
Q11LAPER	LA PERADE	7016840	46.58	11
Q11LOUIS	LOUISEVILLE	7014332	46.28	11
Q11STHCA	S TH CAXTON	7017757	46.36	11
Q11CHAMP	CHAMPLAIN	7011290	46.46	11
Q12ROBER	ROBERVAL	7066685	48.51	12
Q12NORMA	NORMANDIN	7065640	48.85	12
Q12PERIB	PERIBONKA	7065960	48.76	12
Q12BAGOT	BAGOTVILLE	7060400	48.33	12
Q12STAMB	ST-AMBROISE	7066820	48.56	12
Q12LACST	LAC SE-CROIX	7063690	48.41	12
Q12STPRI	ST-PRIME	7067658	48.60	12
Q12BAIEC	BAIE COMEAU	7040440	49.13	12
Q12LESBU	LES BUISSONS	7044288	49.10	12
Q13OTTAW	OTTAWA	6106000	45.31	13
Q13KEMPT	KEMPTVILLE	6104025	45.00	13
Q13AVONM	AVONMORE	6100398	45.16	13

Name of file	Name of station	Number	Latitude	Region
Q13DALHM	DALHOU MILLS	6101958	45.31	13
Q13GLENG	GLEN GORDON	6102832	45.16	13
Q13CHEST	CHESTERVILLE	6101500	45.10	13
Q13MORRI	MORRISBURG	6105460	44.91	13
Q13RUSSE	RUSSEL	6107247	45.25	13

Name of file	Name of station	Period	Latitude
NEW-BRUNSWICK			
NBRBATHU	BATHURST	1956-85	47.62
NBRBUCTO	BUCTOUCHE	1965-85	46.45
NBRFREDE	FREDERICTON CDA	1956-85	45.93
NBRGRAND	GRAND FALLS DRUMM	1956-85	47.01
NBRMONCT	MONCTON A	1956-85	46.12
NBRSUSSE	SUSSEX	1956-85	45.73
NBRWOODS	WOODSTOCK	1956-85	46.16
NOVA SCOTIA			
NSCCLARE	CLARENCE	1958-85	44.93
NSCGREEN	GREENWOOD A	1956-85	44.99
NSCKENTV	KENTVILLE CDA	1956-85	45.07
NSCPUGWA	PUGWASH	1974-85	45.85
NSCSHEFF	SHEFFIELD MILLS	1956-85	45.14
NSCSYDNE	SYDNEY A	1956-85	46.18
NSCTRURO	TRURO	1956-85	45.38
NSCYARMO	YARMOUTH	1956-85	43.85
PRINCE EDWARD ISLAND			
PEICHARL	CHARLOTTETOWN CDA	1956-85	46.29
PEIEASTB	EAST BALTIC	1971-85	46.45
PEISUMME	SUMMERSIDE A	1956-85	46.45
PEITIGNI	TIGNISH	1971-85	46.97
NEWFOUNDLAND			
NFLDEERL	DEER LAKE	1956-85	49.18
NFLGOOSE	GOOSE	1956-85	53.31
NFLGRAND	GRAND FALLS	1956-85	48.96
NFLSTEPH	STEPHENVILLE A	1956-85	48.53
NFLSTJOH	ST.JOHN'S WEST CDA	1956-85	47.51

Name of file	Name of station	Latitude	Period
ONTARIO			
ONTATIKO	Atikokan	48.75	72-86
ONTBELLE	Belleville	44.16	72-86
ONTBRADF	Bradford Muck Research	44.11	74-86
ONTBROCK	Brockville PCC	44.60	72-86
ONTBRUCE	Brucefield	43.55	72-86
ONTCHAPL	Chapleau A	47.83	72-86
ONTCHATS	Chats Falls	45.46	72-86
ONTCOCHR	Cochrane	49.06	72-86
ONTCORNW	Cornwall	45.03	72-86
ONTDELHI	Delhi CDA	42.86	72-86
ONTDORSE	Dorset MOE	45.16	72-86
ONTDURHA	Durham	44.21	79-86
ONTEARLT	Earlton A	47.70	72-86
ONTFORTF	Fort Frances	48.55	72-86
ONTGUELP	Guelph Arboretum	43.55	75-86
ONTHAMIL	Hamilton RBG	43.28	72-86
ONTHARRO	Harrow CDA	42.03	72-86
ONTHORNE	Horne Payne	49.23	71-85
ONTHUNTS	Huntsville WPCP	45.31	72-86
ONTISLAN	Island Falls 49	49.58	72-86
ONTKAPUS	Kapuskasins CDA	49.40	72-86
ONTKEMPT	Kemptville	45.00	72-86
ONTKINGS	Kingston A	44.21	72-86
ONTLONDO	London A	43.03	72-86
ONTMADAW	Madawaska	45.50	72-86
ONTMORRI	Morrisburg	44.91	72-86
ONTNEWLI	New Liskeard	47.50	72-86
ONTNORBA	North Bay A	46.35	72-86
ONTOTTWA	Ottawa CDA	45.38	72-86
ONTPETAW	Petawawa Forest	46.00	72-86
ONTPETER	Peterborough A	44.23	72-86
ONTPICKE	Pickering Audley	43.90	71-85
ONTREDIC	Redickville	44.23	71-85
ONTRIDGE	Ridgetown	42.45	72-86
ONTSARNI	Sarnia A	43.00	72-86
ONTSAULT	Sault Ste-Marie 2	46.53	72-86
ONTSIMCO	Simcoe	42.85	72-86
ONTSMITH	Smithfield CDA	44.08	72-86
ONTSTCAT	St Catharines A	43.20	72-86
ONTSTTHO	St Thomas WPCP	42.76	72-86
ONTSTWIL	St Williams	42.70	72-86
ONTSUDBU	Sudbury A	46.48	72-86
ONTTHUND	Thunderbay A	48.36	72-86
ONTTORON	Toronto	43.66	72-86
ONTTRENT	Trenton A	44.11	72-86
ONTVINEL	Vineland Stn	43.18	72-86
ONTWELLA	Welland	43.00	72-86
ONTWIART	Wiarton A	44.75	72-86
ONTWOODL	Woodslee	42.21	72-86
ONTWOODS	Woodstock	43.13	72-86

Name of file	Name of station	Latitude
ALBERTA: 1972 - 1986		
ALBBROOK	Brooks AHRC	50.55
ALBCALGA	Calgary A.	51.11
ALBCORON	Coronation	52.07
ALBLACOM	Lacombe CDA	52.47
ALBLETHB	Lethbridge CDA	49.64
ALBMEDIC	Medicine Hat A.	50.01
ALBPINCH	Pincher Creek A.	49.51
ALBVEGRE	Vegreville CDA	53.49
BRITISH COLUMBIA: 1972 - 1986		
BRCAGASS	Agassiz CDA	49.25
BRCKAMLO	Kamloops A.	50.71
BRCPRINC	Princeton A.	49.17
BRCQUESN	Quesnel A.	53.03
BRCSAANI	Saanichton CDA	48.62
BRCSUMME	Summerland CDA	49.57
BRCVANCO	Vancouver A.	49.19
BRCVICTO	Victoria A.	48.66
MANITOBA: 1972 - 1986		
MANBRAND	Brandon CDA	49.93
MANDAUPH	Dauphin A.	51.11
MANGIMLI	Gimli	50.62
MANMORDE	Morden CDA	49.19
MANPILOT	Pilot Mound Point	49.21
MANPORTA	Portage A.	49.91
MANRUSSE	Russell	50.77
MANSWANR	Swan River	52.12
MANWINNI	Winnipeg A.	49.91
SASKATCHEWAN: 1972 - 1986		
SASESTEV	Estevana	49.07
SASINDIA	Indian Head CDA	50.53
SASKINDE	Kindersly A.	51.47
SASMAPLE	Maple Creek North	50.00
SASMOOSE	Moose Jaw A.	50.35
SASMOOSO	Moosomin	50.16
SASREGIN	Regina CDA	50.41
SASSASKA	Saskatoon SRC	52.18
SASSCOTT	Scott CDA	52.38
SASSTRAS	Strastourg	51.07
SASSWFTC	Swift Current CDA	50.27

ANNEX D. FILE STRUCTURE

The software uses 8 files, of which 3 are sequential and 5 are direct access files. During the execution, 4 files will be opened at the same time. Sequential files can be modified with any editor.

Name of the file	Type	Option to choose	Description
Site.NOR	Direct	none	Normals
Site.MET	Direct	2	Data
Site.SOL	Direct	1	Soils
Site.INI	Sequential	1	Miscellaneous
Site.IRR	Sequential	3	Irrigation
Site.PHE	Sequential	4	Phenology
Site.SUP	Direct	6	Comments
Site.C1	Direct	5	Measurements

Each file will be described in detail.

D.1 File of normals (Site.NOR)

This file is provided on a supplemental diskette. It contains the normals for the nearest meteorological station. The first record contains the data on April 1st and so on until October 31st. Each record contains the following information:

Qo (1- 7): global radiation at the top of the atmosphere in g-cal/cm^2/day
EP (8-14): potential evapotranspiration in mm
TX (15-21): mean maximum temperature in Celsius
TN (22-28): mean minimum temperature in Celsius
(29-35): free space for further use

Qo is used in the calculation of the daily potential evapotranspiration. EP is used in the estimation of the numbers of days in which the next irrigation is required.

Option 0 can be used to define a normals file for each site being used.

D.2 File of meteorological data (Site.MET)

This file must be provided (option 2) by the user before every execution of the budget. When one starts a new growing season, the file of the previous year should be stored under another name (for example: COPY Farmsite.MET FARM85.MET will save the meteorological data of 1985 on file FARM85.MET). The conditions of the next week can be simulated by using either the normals (provided on file Site.NOR) or last year's data.

The first record refers to the data on April 1st and so on. Each record has the following structure:

TX (1- 7): daily maximum temperature on the farm (celsius)
TN (8-14): daily minimum temperature on the farm (Celsius).
PR (15-21): daily precipitation in mm on the farm
PET (22-28): daily potential evapotranspiration, calculated by the program

TX and TN are used (along with Qo from the normals file) to calculate PET. This variable is used to estimate the amount of water transpired by the plant and evaporated by the soil. PR is the input of water into the soil by rain.

D.3 File of irrigation data (Site.IRR)

This file must be updated by the user after each irrigation (option 3). It must be created again at the beginning of every growing season. However, the file of the previous year can be saved under another name.

This file is sequential. Every record contains the following information: IC, IJ, IR

IC: field number
IJ: day from the first of april
IR: water added in mm

field no 1, day 1, amount
field no 1, day 2, amount
.
.
field no 2, day 1, amount
etc.

The variable IR is used in the irrigation budget to estimate the anount of irrigation water added to the soil.

D.4 File of phenological data (Site.PHE)

This file contains information relative to the crop. It is a sequential file. For each field, the following information is stored:

Record 1: CH$,ST%,SS (one for each field)

CH$: name of the crop
ST% : number of stages
SS : critical deficit (%/100)

record 2: NOMK$,DP% (one for each stage)

NOMK$: name of the stage
DP% : date of occurence

record 3: K (one for each zone)

K : crop coefficient

For example, for a site containing one field, 2 stages and 2 zones, the order will be:

Record 1
record 2
record 3
record 3
record 2
record 3
record 3

D.5 File for initialization (Site.INI)

This file is created with option 1, once a year. It is sequential and it contains the following information:

Record 1: IA%, NC%

- IA%: current year. Used when the results are printed
- NC%: number of fields to be managed. Maximum = 5. This maximum can be changed: see annex D

Record 2: N$,WC%,DD%,RM,RI,W2%,R$,VW

- N$: name of the field
- WC%: number of zones in soil profile of the field
- DD%: starting date for the field this is the date for which an initial soil moisture value was provided
- RM : maximum available water for the profile of the field
- RI : actual available water content (date DD%) for the profile of the field
- W2%: number of zones (+1) drained the first day following rain or irrigation
- R$: indicator of a water table (Yes or No)
- VW : initial water table height (depth in cm)

This record is repeated for every field. Record 2 must be repeated NC% times.

Record 3: WG(7)

Default fixed drainage parameters, one by line.

- WG(1): maximum amount of water in mm drained between surface and first drainage layer
- WG(2): maximum amount of water in mm drained between the first layer and the second layer of drainage
- WG(3): maximum amount of water in mm drained through the bottom of the root zone
- WG(4): rate of drainage between the 2 layers (fixed to 1)
- WG(5): rate of runoff (fixed to 1)
- WG(6): lateral drainage in mm for the water table
- WG(7): capacity of the reservoir below the root zone only if there is a water table.

Record 3 is repeated seven times for every field.

Order of the records is the following:

```
Record 1
Record 2, field 1
Record 3, field 1
Record 2, field 2
Record 3, field 2
Etc.
```

D.6 File of soil characteristics (Site.SOL)

This is a direct access file, created with option 1. Every record describes a zone of soil in the profile and is repeated for every field.

WP (1- 7): depth from soil surface to bottom (?) of zone in cm
WX (8-14): percentage of water (%) retained in excess (of field capacity) by the soil of the zone
WA (15-21): field capacity in % for the zone
WW (22-28): permanent wilting point (%)
WH (29-35): actual available water content in %
ZR (36-42): soil parameter
ZM,ZN,ZH (43-57): fixed at 1,0,0. Linear effect of the soil.

The order is the following:

```
field 1, layer 1
field 1, layer 2
   .
field 1, layer 6
field 2, layer 1
   .
field 2, layer 6
etc
```

D.7 File of supplementary information (Site.SUP)

This file is used to collect all supplementary information which can be used to interpret the results. It is a direct access file but it is not used in the calculations.

Each record is coded with a key and the information:

Key (1- 3): indicator of a record on a date
Info (4-73): information

There is one record for each date.

D.8 File of observed soil moisture data (Site.C1)

Observed soil moisture values are kept in this file when they are reported with option 5. There is one file for each field reporting observations.

It is a direct access file and the values are used by the software to correct itself. However, these files are optional. They are used only if they exist.

Every record contains two variables: soil moisture in a zone and a key. The order of the records is the following:

```
Day1, zone1
Day1, zone2
  .
Day2, zone1
  .
```

If there is only one zone, then zone 1 refers to the profile.

D.9 File for Archived Meteorological data

This file will be used by "CONVERT" to calculate site normals. It's format must always be ASCII.

station number	(1-7)	- not used (re. archive)
year	(8-9)	- not used (re. archive)
month	(10-11)	
day	(12-13)	
Tmax	(14-17)	- daily maximum temperature
Tmin	(18-21)	- daily minimum temperature
	(22-29)	- not used (re. archive)
Prec	(30-33)	- total daily precipitation
	(34-44)	- not used (re. archive)
Pe	(45-48)	- Potential evapotranspiration

Annex E: Irrigate Files Management System with CONVERT

The software CONVERT is a file management system which allows the user to convert files in ASCII to files created with IRRIGATE and the reverse. Two formats are available:

- ASCII format: standard code that can be displayed on the screen. Default format is described in Annex D.9.
- IRRIGATE format: binary code. Format of the files are described in Annex D.1 for normal (.NOR) files and Annex D.2 for meteorological data files (.MET).

The CONVERT files management system is comprised of a series of programs that will do the following:

1. Convert existing Irrigate meteorological data files to ASCII format

2. Convert existing ASCII format meteorological data files to Irrigate format

3. Create Irrigate normal data file for Irrigate from ASCII files

4. List Irrigate normal data records

5. List Irrigate meteorological data records

6. Run Irrigate

7. Backup Irrigate files

This system is activated by a main menu. It is programmed to respond to the user in either official language.

The software provided was compiled on an IBM-PC compatible microcomputer using Microsoft Quickbasic compiler version 4.0. It requires the nine programs that appear in figure E.1.

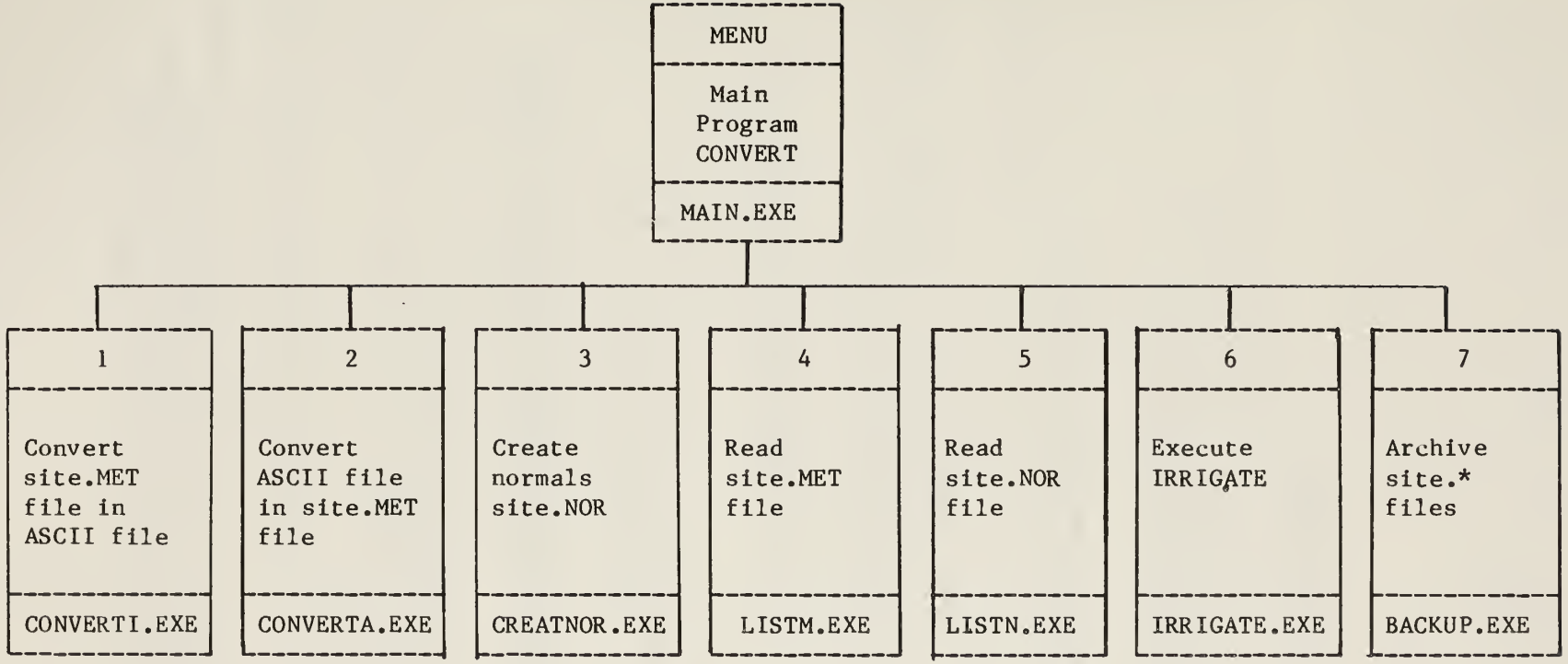

Figure E.1: System flowchart of programs and options.

System Details and uses

After inserting the file management system diskette in drive A, the user can activate this system by typing:

```
A > Convert
```

The system will respond with the following :

```
                Agriculture Canada
            Irrigate Files Management System/
          Systeme de Gestion des Fichiers Irrigue

      Indicate the language of your choice (E OR F)
      Indiquer la langue de votre choix    (E OU F)

      ?
```

The software is designed to be run in either official languages. This question is only asked once at the first use of the package. Then a file named LANGUAGE.DAT is created.

Once the user has choosen E, the system will display the following menu :

```
                Agriculture Canada
            Irrigate Files Management System
                      Main Menu

      1. Convert Irrigate meteorological data file to ASCII format
      2. Convert ASCII format meteorological data file to Irrigate
         format
      3. Create a file of Irrigate normal records
      4. Read Irrigate meteorological records
      5. Read Irrigate normal records
      6. Run Irrigate
      7. Backup Irrigate files
      8. To Finish

      Enter your choice ?
```

A number is entered according to the option chosen. End by typing the <enter> key or option 8. Each option will be explained except for option 6.

Option 1: Convert Irrigate Meteorological file to ASCII format

This program converts an Irrigate meteorological file (see Annex D.2 Irrigate) to an ASCII format file (see Annex D.9 Irrigate for default). This file may then be used as input to "Create Normals" (option 3).

The system will display the following:

```
                    Agriculture Canada
                Irrigate Files Management System
            Convert Irrigate Meteorological file to ASCII FORMAT

        Name of "Irrigate" meteorological file to read
    or press  enter> to return to main menu: ? FARMSITE.MET ↵
```

You respond with a file created with IRRIGATE which usually has the extension .MET

Type ↵ to return to the main menu. If the file does not exist, a message is displayed:

```
    File not found:  FARMSITE.MET
```

Re-enter the name correctly. Then, enter the name of the new file.

```
   Name of meteorological file to create in ASCII format ? FARMSITE.ASC

   One moment please...
```

A file will be created that may be read with TYPE and PRINT or modified by an editor.

User can define the format of the output record or use default format (annex D.9).

```
      Specify the format of your file : FARMSITE.ASC

   1. Default format

   2. User's format

      Enter your choice : ? 2
```

With option 1, the system will create a file as described in annex D.9. It is the standard archive format at Agriculture Canada.

With option 2, the user specifies the organisation of the parameters (maximum and minimum temperature, precipitation and evapotranspiration) in terms of location and lengths in the record.

```
MONTH : Field start position in record ? 1 ↵
MONTH : Length of field in record      ? 2 ↵

DAY : Field start position in record ? 3 ↵
DAY : Length of field in record      ? 2 ↵

TEMP.MAX. : Field start position in record ? 5 ↵
TEMP.MAX. : Length of field in record      ? 7 ↵

TEMP.MIN. : Field start position in record ? 12 ↵
TEMP.MIN. : Length of field in record      ?  7 ↵

PREC : Field start position in record ? 19 ↵
PREC : Length of field in record      ?  7 ↵

ETP : Field start position in record ? 26 ↵
ETP : Length of field in record      ?  7 ↵
```

Maximum record length allowed is 60. Missing values are written as 999 on the output file.

Main menu is then displayed again.

Option 2: Convert ASCII format meteorological file to Irrigate format

This program converts an existing ASCII format file to an Irrigate meteorological file. If the evapotranspiration (PE) is missing this program will calculate it based on the solar radiation for the site latitude and the available maximum and minimum temperatures. This file may then be used as input to Irrigate.

The system will display the following :

```
                    Agriculture Canada
                Irrigate Files Management System
    Convert ASCII code meteorological data file to Irrigate Format

       Enter the latitude of your site (Deg.min) ? 45.4 ↵

       Hit <enter> or ↵  to return to main menu : ? 45.4 ↵

       One moment please----------
```

Latitude is required to estimate the global radiation at the top of the atmosphere. The data are used to estimate the potential evapotranspiration. Type ↵ to return to main menu.

Provide the name of the ASCII file to be read and converted.

```
       Name of ASCII format meteorological file to read ?
```

An error message will be displayed if the file does not exist. Check the spelling or exit from the program and check the directory.

Indicate the format of the input record. There are two options.

```
       Specify the format of your file : FARMSITE.ASC

    1. Default format

    2. User's format

       Enter your choice : ? 2
```

Option 1 is the default format as described in annex D.9.

With option 2, the user has to specify the position and the length of each parameter (maximum and minimum temperature, precipitation and evapotranspiration) into the input record. If evapotranspiration values are missing they will be estimated using the latitude and the temperature.

```
MONTH : Field start position in record
or if missing hit ↵   ? 2
MONTH : Length of field in record : ? 2
```

If there is no date in the record, this one will be determined by the position of the record on the file. Starting date must be provided.

```
MONTH : Field start position in record
or if missing hit ↵   ?  ↵

Enter start date (format month day = 0401) : ? 601 ↵

TEMP.MAX. : Field start position in record ? 1 ↵
TEMP.MAX. : Length of field in record      ? 7 ↵

TEMP.MIN. : Field start position in record ? 8 ↵
TEMP.MIN. : Length of field in record      ? 7 ↵

PREC : Field start position in record ? 15 ↵
PREC : Length of field in record      ? 7  ↵

ETP : Field start position in record
or if missing hit ↵   ? 22 ↵
ETP : Length of field in record      ?  7
```

Maximum record length allowed is 60. Missing values are written as 999 on the output file.

```
Enter name of Irrigate meteorological file : ? FARMSITE.MET ↵

One moment please.....

Records converted from 4 1 to 6 21
Press any key to continue ?
```

Give a site name with the extension .MET to get a file directly useable by IRRIGATE.

Then main menu is displayed.

Option 3: Create a file of Irrigate normal records

This option allows you to create a normal data file that will be used in IRRIGATE to forecast the next irrigation.

This program reads one or more ASCII meteorological files to create an internal basic "normal" file (see. Annex D.1 Irrigate). The files must all have the same format and must cover the same period within a year. The files can be created:

- with option 1
- with archive format defined in annex D.9
- with a user format with a maximum record length of 60.

This program also calculates global radiation based on the input site latitude. Using the global radiation, maximum and minimum daily temperatures it will also calculate PE where such is missing.

In calculating site normals this program will accept more than 1 year of daily meteorological values. However, a file must contain only one year at a time.

The system will display the following :

```
                Agriculture Canada
          Irrigate Files Management System
        Create Irrigate Normal Data Records


      Enter your site name ? FARMSITE ↵
```

Reply with your site name. For the definition of 'site' see section 1.0, second part of the guide. The software creates normal file and adds the extension .NOR after the site name (site.NOR).

The latitude of the site is required to calculate global radiation. Value is entered as degree and minutes.

```
      Enter the latitude of your site (deg.min)  ? 45.3 ↵

      One moment please...
```

Then enter the name of an existing ASCII file that contains one year's meteorological data.

```
Enter the name of ASCII format meteorological file  ? FARMSITE.ASC
```

The user is asked to define his input record format from two options.

```
   Specify the format of your file : FARMSITE.ASC

1. Default format

2. User's format

   Enter your choice : ? 2 ↵
```

Option 1 is the default format as described in annex D.9.

With option 2, the user has to specify the position and the length of each parameter (maximum and minimum temperature, precipitation and evapotranspiration) into the input record. If evapotranspiration values are missing they will be estimated using the latitude and the temperature.

```
MONTH : Field start position in record
or if missing hit ↵   ? 2 ↵
MONTH : Length of field in record : ? 2↵
```

If there is no date in the record, this one will be determined by the position of the record on the file. The starting date must be provided.

```
MONTH : Field start position in record
or if missing hit ↵   ? ↵

Enter start date (format month day = 0401) : ? 601↵

TEMP.MAX. : Field start position in record ? 1
TEMP.MAX. : Length of field in record      ? 7↵

TEMP.MIN. : Field start position in record ? 8↵
TEMP.MIN. : Length of field in record      ? 7 ↵

PREC : Field start position in record ? 15↵
PREC : Length of field in record      ? 7  ↵

ETP : Field start position in record
or if missing hit ↵   ? 22 ↵
ETP : Length of field in record      ?  7
```

Maximum record length allowed is 60.

After processing your input meteorological file the program will display the following prompt :

Do you have another file for this site (Y OR N) ?

If the answer is "Y", you will be requested to supply another meteorological file. The format must be the same as previously defined.

If the answer is "N", the normal file is created with the extension site.NOR

Option 4: Read Irrigate Meteorological Records

This option allows the reading of any meteorological file created with option 2 or with the IRRIGATE software.

The system will display the following :

```
                    Agriculture Canada
                Irrigate Files Management System
            Read Irrigate Meteorological Data Records

  Name of Irrigate meteorological file to read
  Or hit ↵  to return to main menu            : ? FARMSITE.MET
```

Enter the name of an IRRIGATE format file. Return to main menu by typing ↵ .

Records can be displayed or printed for a selected period or all the file.

The system will respond with the following :

```
        Hit <*> to read all records
            <enter> for a period
            <-> to exit              : ?
```

For period records the system asks for the beginning and the end. The following exemple shows how to display only one day:

```
        From (for ex. 401 means 1 April ) ? 401 ↵
        To   (for ex. 430 means 30 April) ? 401 ↵
```

The Irrigate meteorological file contains records from April 1 to October 31 inclusive. Missing values are displayed with 9999.

Data can be displayed or printed. The system asks the following :

```
        Hard copy (P) or screen (S) ?
```

If hard copy is your option be sure to put the printer in ready status.

The system displays the following on printer or screen :

```
The file FARMSITE.MET contains 78 records

          Day        T.Max      T.Min      Prec.     Pe

          401         7.2       -3.4        1.2      0.6
```

Data provided is the date (Day = month, day), the maximum temperature (T.Max), the minimum temperature (T.Min), the precipitation in mm (Prec) and the potential evapotranspiration (Pe).

After each 20 lines of output the system displays the following message:

```
        Press any key to continue or <-> to stop ?
```

After displaying according to the user's request the system displays the following :

```
        End of request - Hit any key to continue ?
```

Option 5: Read Irrigate Normal Records

This option allows the user to print any normals files used by IRRIGATE or created with option 3.

The system will display the following :

```
                    Agriculture Canada
                Irrigate Files Management System
                Read Irrigate Normals Records


      Irrigate normals file name to read
      Or  enter> or ↵ to return to main menu     : ? FARMSITE.NOR
```

The user's response to this prompt is a normal IRRIGATE file. Type to return to main menu.

The system will respond with the following :

```
          Hit <*> to read all records
              <enter> for a period
               <-> to exit              : ?
```

For period records, the user is asked for the beginning and the end of the period. The following exemple shows how to display one day:

```
          From (for ex. 401 means 1 April ) ? 401↵
          To   (for ex. 430 means 30 April) ? 401↵
```

The Irrigate "Normals" file contains records from April 1 to October 31 inclusive. Missing values are stored as 9999.

Data can be displayed on screen or printed. The system displays the following :

```
          Hard copy (P) or screen (S) ?
```

If hard copy is your option be sure to put the printer in ready status.

The system displays the contents of the file on printer or screen :

```
The file FARMSITE.MET contains 214 records

   Day      Radiation     Pe     T.Max     T.Min

   401        712.4       0.6      7.2      -3.4
```

Data displayed are the date (Day = month, day), the global radiation at top of the atmosphere (Radiation), the potential evapotranspiration (Pe), the normal daily maximum temperature (T.Max) and the normal daily minimum temperature (T.Min).

After each 20 lines of output the system displays the following message:

```
Press any key to continue or  .  to stop ?
```

After displaying according the user's request the system displays the following :

```
End of request - Hit any key to continue ?
```

Then the main menu is displayed again.

Option 7: Backup Irrigate Files

This program will backup any set of IRRIGATE files when a sitename is given.

The program will display the following:

```
                Agriculture Canada
          Irrigate Files Management System
                Backup Irrigate Files


     Enter your site name ? FARMSITE ↵

     Enter new site name or  enter> for the same ? FARM87 ↵

     Enter source drive and directory ? ↵

     Enter target drive and directory ? A:\↵
```

Type ↵ if the files have to be read or written on the actual drive. Otherwise type A: or B: or C:. If a directory name is given, add the "\" at the end (C:\IRRIG\).

```
     Insert diskette in drive  A:

     Hit any key when ready
```

During the back up process the program displays the following for each file it finds :

```
       COPY FARMSITE.INI FARM87.INI
```

At the end of job the program displays:

```
     Number of files backed up for FARMSITE = 9
```

If no files were backed up the program will display

Found no files to back up for FARMSITE

This program does not check for the availability of space on the user diskette for the files being backed up. Main menu is displayed again.